

Approaches & Techniques_____

A Managerial Accounting Analysis of Hospital Costs

by Werner G. Frank

Variance analysis, an accounting technique, is applied to an eight-component model of hospital costs to determine the contribution each component makes to cost increases. The method is illustrated by application to data on total costs from 1950 to 1973 for all U.S. nongovernmental not-for-profit short-term general hospitals. The costs of a single hospital are analyzed and compared to the group costs. The potential uses and limitations of the method as a planning and research tool are discussed.

A variety of techniques have been used to analyze the total costs incurred by hospitals. Most involve a comparison of the actual costs incurred during a given period with some level of cost considered to be an appropriate basis for comparison. These base levels may be derived in several different ways. One micro-level approach uses industrial engineering studies of the basic tasks involved to develop standard times and costs for each task component. The total actual costs are then compared to the total standard costs allowed for the activity level prevailing during the period. Macdonald and Reuter [1] used this approach to cost obstetrical services at Johns Hopkins Hospital. They illustrated how a detailed costing of medical staff activities could provide a more meaningful basis than the traditional listing of actual costs for evaluating the expenses incurred in operating the delivery suite.

Another alternative is statistical regression analysis to develop a cost function in which total costs are modeled as a function of one or more explanatory variables. An example of this approach is the study by Lave and

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Lave [2] in which they evaluated effects of such variables as the hospital size, utilization of hospital services, and an inflationary effect related to time on the costs of a group of Pennsylvania hospitals. Feldstein's study of Methodist Hospital in Gary, Indiana [3] illustrates how this approach may be applied to an individual hospital. He analyzed the monthly operating expenses of thirteen departments, and then combined the individual departments' cost functions to derive a total cost equation for the hospital. Feldstein was particularly interested in using the results of this study to identify the amount of the hospital's short-run marginal costs.

A third possibility is to compare a hospital's costs to costs incurred by similar organizations over the same period of time. This approach underlies such reporting services as that provided by Hospital Administration Services (HAS). A hospital subscribing to this service reports its own costs, which HAS incorporates into a distribution of costs. A hospital may then evaluate its own costs by seeing where it falls in this distribution.

All three of these approaches have much to recommend them; however, each requires an elaborate data base before it can be used. An alternative approach to cost analysis which has much more modest data requirements has been developed by managerial cost accountants. Although most of the discussion in the accounting literature has been oriented to industrial applications, the technique itself is quite general and can be applied to a wide variety of activities and types of organizations.

This technique is often referred to in accounting as variance analysis; it is not, however, related to the statistical analysis of variance procedure. In accounting usage, the term "variance" simply refers to a difference between two amounts. The basic accounting technique is described in most standard cost and managerial accounting texts [4]. Variance analysis involves two essential steps: the specification of an appropriate total cost model in the form of an identity, or definitional relationship; and the decomposition of the change, or difference, between two cost totals into a set of separate cost changes, or variances, one for each of the individual components or factors in the initial cost model.

This approach has been quite useful in a variety of situations as an initial screen to identify areas in which a more detailed study would be useful. The analysis does not, however, provide evidence about *why* the factors in the initial cost model have changed. Its use is not so much explanatory as descriptive.

PRICE-VOLUME CHANGE ANALYSIS

The analysis of a change in total costs in terms of changes in volume and unit prices is a simple form of variance analysis. In this application, the total cost model is defined as total usage times unit cost or $C = VU$, where C denotes total cost, V is total admissions, and U is cost per admission.

This model may be graphed with a vertical axis corresponding to unit cost and a horizontal axis showing total usage or volume. The amount of total

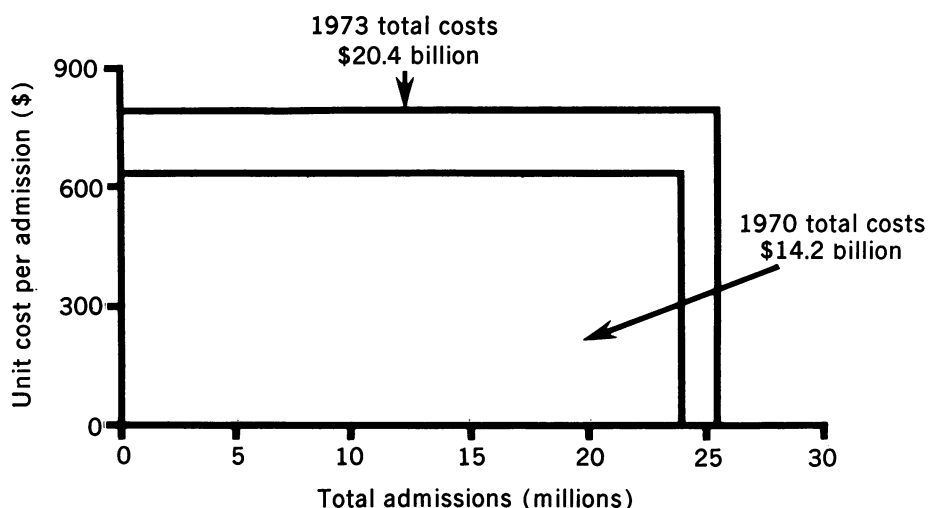


Fig. 1. Change in total cost with change in cost per unit and number of units.

costs is then represented by the rectangle formed by the two axes and a horizontal and a vertical line drawn at the unit cost and usage level respectively. Figure 1 illustrates the total costs of all U.S. nongovernmental (voluntary) not-for-profit short-term general hospitals for two years, 1970 and 1973, when the total costs were \$14.2 and \$20.4 billion, respectively. In these two years admissions were 22.9 and 25.2 million (including an adjustment for outpatient visits), and the unit costs per admission were \$619 and \$811, respectively.

This graphical representation suggests a convenient and natural way to assign the \$6.2 billion increase in total hospital costs to price and usage effects. If the unit cost in 1973 had remained at the 1970 level, \$619 per admission, but usage had increased by 2.3 million admissions (from 22.9 to 25.2 admissions), total hospital costs would have increased by \$1.4 billion (2.3 million increased admissions times \$619 per admission, or \$1.4 billion). This amount, the volume variance, is the change in total costs attributable to the increased usage of hospital facilities; it is shown in Fig. 2 as the area shaded with vertical lines.

If admissions had remained constant at 22.9 million while the unit cost per admission increased from \$619 to \$811 per admission, the total costs would have increased by \$192 per admission times 22.9 million admissions, or \$4.4 billion. This unit cost variance is shown by the area shaded with horizontal lines in Fig. 2. Because both unit costs and admissions increased over this period, another smaller amount, the product of the 2.3 million increase in admissions times the \$192 increase per admission, or \$0.4 billion, is needed to account for the total increase in cost. This amount is shown by the cross-hatched area in the upper right corner of Fig. 2. These three amounts, the \$1.4

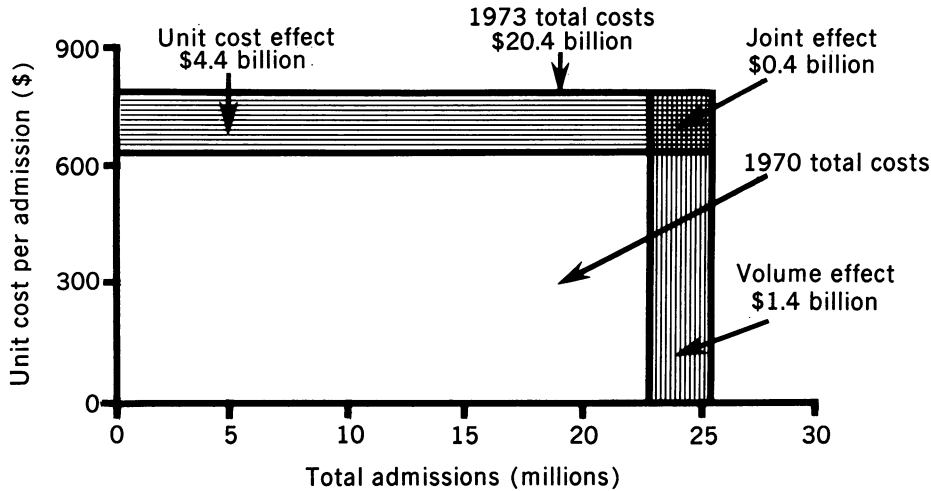


Fig. 2. Attribution of total cost change to unit effect and volume effect.

billion volume effect, the \$4.4 billion unit cost effect, and the \$0.4 billion joint volume-unit cost effect, sum to the \$6.2 billion overall increase in total costs.

The \$0.4 billion joint cost-volume effect is due to a simultaneous change in both unit costs and volume; had there been no change in one of these components, this joint effect would not exist. The joint effect, or joint variance, is sometimes set out separately, and sometimes, for convenience, combined with the other variances. In this article the joint variance is assigned to the other factors in proportion to their relative size, as suggested by Bashan et al. [5]. This assignment results in adding \$0.3 billion of the \$0.4 billion joint variance to the volume variance, increasing it to \$4.7 billion, and increasing the unit cost variance by the remaining \$0.1 billion of the joint variance, so that it now totals \$1.5 billion. This treatment of the joint variance is generally neutral in its effect on the relative size of the volume and unit cost variance: in most cases, these variances after allocation of the joint variance will bear the same proportional relationship to each other as did the individual variances initially computed.

AN EIGHT-FACTOR MODEL OF TOTAL HOSPITAL COSTS

Within the framework of the total cost identity, $C = VU$, the volume and unit cost components can be broken down in turn into several more specific factors. Such a breakdown can provide greater insights into the reasons why the volume of admissions and unit costs increased.

One breakdown is illustrated below. It is an elaboration of a basic view of hospital costs that was used by Andersen and May in analyzing the increasing hospital costs in the 1960s [6]. In the model described below, the

number of admissions (V) is defined as equal to the population served times the equivalent admission rate for inpatient care. The equivalent admission rate includes outpatient visits converted to equivalent inpatient days on the basis of 5.74 outpatient visits = one inpatient day. This equivalence is derived from the ratio of hospital revenues from outpatient visits to revenues from inpatient days of care, the conversion developed and used by the American Hospital Association in the annual publication *Hospital Statistics* (formerly the Guide Issue of *Hospitals*). The true value of this conversion ratio varies annually. For the illustrative purposes of this article, the 5.74:1 ratio is used throughout; this ratio was applicable in 1970 [7] and is the one used by Andersen and May [6] in their analysis of hospital costs.

After outpatient visits are converted to equivalent inpatient days, the patient-day equivalent is divided by the current year's average length of stay to provide a volume measure comparable to inpatient admissions. It is then reexpressed as an equivalent admission rate per million population served. The resulting rate is added to the inpatient admission rate. Thus total admissions, V , may be calculated from

$$V = P(A + O) \quad (1)$$

where P = population served, in millions

A = inpatient admissions per million population

O = outpatient equivalent admissions per million population

The unit cost per patient day includes two major components of cost: labor or wage costs, and nonwage costs (e.g., supplies and depreciation of buildings and equipment). Both the wage and nonwage components are deflated by an appropriate price index. To account for the differing rates of inflation which have affected wage and nonwage costs, labor costs are deflated by the Department of Labor's U.S. hourly earnings series [8], while nonwage costs are deflated by the wholesale price index [9]. Both series are restated so that 1950 = 1.00. The combined effect of deflating these two components separately is then reexpressed as an implicit price deflator, analogous to the deflation of the economy's gross national product by the implicit GNP price deflator. This computed price deflator is used as a measure of the inflation of hospital costs. Deflated wage costs, in turn, are expressed as the product of the number of employee days per patient day times the (deflated) wage rate per employee day. Since unit costs are expressed per patient day, the cost per patient day must be multiplied by the average length of stay to determine U , the unit cost per admission:

$$U = I(WS + N)L \quad (2)$$

where I = inflation index, 1950 = 1.00

W = deflated wages per employee day

S = staffing level: employee days per patient day

N = deflated nonwage costs per patient day

L = average length of stay, in days

Combining Eqs. 1 and 2, total hospital costs can now be expressed as follows:

$$C = P(A + O)I(WS + N)L \quad (3)$$

This more detailed expression of total costs can readily be adapted to account for the impact on total costs of changes in each of the eight factors. Essentially this procedure involves determining the magnitude of the effect attributable to the change in any given factor by a computation that incorporates the change in that factor along with the base period values for other factors. As an example, that part of the change in total hospital costs from 1970 to 1973 that is attributable to the increase in population would be computed as follows:

$$\Delta_P C = (P_{73} - P_{70})(A_{70} + O_{70})I_{70}(W_{70}S_{70} + N_{70})L_{70} \quad (4)$$

A similar equation can be written for each of the eight factors.

Joint effects become much more cumbersome in a more complex model such as this eight-factor model. Not only are there numerous 2-factor joint effects, e.g., those attributable jointly to the increase in population and the increase in admission rates, but 3-factor, 4-factor, and so on up to 8-factor joint effects occur. However, the procedure mentioned previously can still be used to deal with joint effects: the total of all joint effects is apportioned among the individual single-factor variances, the main effects, in proportion to their relative size. In the case represented by Eq. 4, $\Delta_P C$, the population variance in total cost, constitutes approximately seven percent of all the single-factor variances. Therefore seven percent of the combined joint variances is added to the population variance.

AN ANALYSIS OF 1950-1973 HOSPITAL COSTS

Data from the annual surveys conducted by the American Hospital Association [10] were used to calculate the values of each of the eight factors in Eq. 3 for the years 1950-1973. (Prior to 1961, outpatient visits were not reported separately, so it was not possible to determine the effect of changes in this factor for the first two five-year periods. Judging from the data for the first years in which they were reported, however, the effect is probably small. An estimate of outpatient visits in 1960 is contained in Andersen and May [6, p. 66], and this estimate was used to quantify the outpatient effect for the 1960-65 period.) While large increases occurred in most of the eight factors over this 23-year period, it would be difficult to assess the relative impact of each factor on total hospital costs without a formal analytical model. The model that has been described provides such a framework, and it has been used to calculate the amount of the total change attributable to each of the eight factors for the five-year periods 1955-60, 1960-65, 1965-70, and the three-year period 1970-73. These amounts both before and after the allocation of joint variances, and the percentage of the total increase in hospital costs accounted for by each factor, are shown in Table 1.

Table 1. Contributions of Volume and Unit Cost Factors to Changes in Total Hospital Costs, 1950-1973

Period	Total increase in hospital costs (\$ millions)	Factor contributions (\$ millions)							Length of stay ($\Delta_L C$)	Joint effects (\$ millions)
		Population served ($\Delta_P C$)	Admissions		Inflation rate ($\Delta_I C$)	Deflated wage ($\Delta_W C$)	Staffing level ($\Delta_S C$)	Deflated nonwage costs ($\Delta_N C$)		
			inpatient ($\Delta_I C$)	outpatient equiv. ($\Delta_O C$)						
1950-55	985	123	158	*	288	104	73	107	-40	172
with joint effects										
allocated	985	147	189	*	343	124	87	127	-32	...
Percent of total	100	15	19	*	35	12	9	13	-3	...
1955-60	1 631	232	269	*	401	43	159	274	-33	286
with joint effects										
allocated	1 631	279	324	*	482	52	191	330	-27	...
Percent of total	100	17	20	*	29	3	12	20	-1	...
1960-65	2 504	311	206	60	394	151	163	630	168	421
with joint effects										
allocated	2 504	374	247	72	474	182	196	757	202	...
Percent of total	100	15	10	3	19	7	8	30	8	...
1965-70	7 520	350	293	162	1 361	444	490	2 172	431	1 817
with joint effects										
allocated	7 520	462	386	214	1 794	585	647	2 863	569	...
Percent of total	100	6	5	3	24	8	9	38	7	...
1970-73	6 255	457	518	414	2 816	115	363	1 626	-691	636
with joint effects										
allocated	6 255	498	566	452	3 071	126	396	1 774	-628	...
Percent of total	100	8	9	7	49	2	6	29	-10	...

* Outpatient visit equivalents not reported until 1961.

The relative importance of the three usage factors—population served (P), inpatient admission rates (A), and outpatient equivalent admissions (O)—is significantly less than the combined impact of those factors relating to unit costs. The combined usage effects accounted for less than 40 percent of the total increase in hospital costs in all of these periods and dropped to less than 15 percent over the 1965–70 period. This decline in the usage effects came as a result both of the post-1965 decline in the growth of the population served and a leveling off of the increase in the inpatient admission rate in the '60s, while factors affecting unit costs continued their rapid growth.

Table 1 illustrates the impact of inflation in the 1970–73 period. Inflation alone accounted for about half of the entire increase in hospital costs over this period. Another striking contribution highlighted by the analysis is the growing impact of (deflated) nonwage costs per patient day. Though deflated, the cost increase of supplies, equipment, and the like has grown faster than inflation: from a 13-percent share of total cost increases over 1950–55 to a 38-percent share over 1965–70. This represents a more than 20-fold rise in deflated dollars per patient day between 1950 and 1970, while the dollar amount of inflation in both wage and nonwage costs increased about 5-fold over the same period. This increase in nonwage costs probably reflects in part the modernization of facilities and the spread of expensive new medical technologies that have occurred over the past 20 years.

PLANNING AND RESEARCH USES

The above analysis illustrates the historical or retrospective application of the model. The same cost framework can also be used to forecast and plan for hospital costs over some future period.

Such forecasts can be made in a variety of ways; the calculation of exponentially smoothed moving averages [11] is one method that has given reasonably accurate results. This technique was applied to annual data for each of the eight factors for the ten-year period 1964–73, and the forecasts for

Table 2. Average Absolute Percentage Errors in Ten Annual Forecasts of Eight Factors Affecting Hospital Costs

Factor	Ten-year average of absolute forecast errors (%)
Population, millions (P)	0.5
Inpatient admissions per million population (A)	1.0
Outpatient equivalent admissions per million population (O)	10.5
Inflation factor (1950 = 1.00) (I)	1.1
Deflated wages per employee day (W)	3.1
Staffing (employee days) per patient day (S)	2.3
Deflated nonwage costs per patient day (N)	3.0
Length of stay, in days (L)	1.3
Total annual hospital costs computed from forecasts (C)	2.6

each year were substituted in Eq. 3 to calculate an estimate of total hospital costs for that year. The average absolute errors over the ten annual forecasts of each factor are shown in Table 2. With two exceptions, they range from one to three percent. The population forecasts showed a ten-year average absolute error of only 0.5 percent, while the absolute error in outpatient equivalent admissions averaged 10.5 percent over the ten forecasts. The instability in the latter factor may be a result of the increasing use of hospital emergency rooms as primary care sources. The absolute errors of the ten annual estimates of total hospital costs averaged 2.6 percent, which seems acceptably accurate for most planning purposes. It should be noted that this level of accuracy was achieved in forecasts made one year in advance; forecasts made for five or ten years in the future might be expected to show rather higher error levels.

Given the factor values, whether forecasted or from current data, the cost model expressed in Eqs. 3 and 4 lends itself to various analytical investigations. For example, sensitivity analysis reveals that a 10-percent increment in population served would increase total costs by 10 percent, whereas a 10-percent increment in staffing level or wage rate would increase total costs by about four percent. If the extent to which outpatient services can substitute for inpatient care were determined, the cost consequence of this substitution could be readily investigated. With a more detailed breakdown of, say, nonwage costs, the effects of changes in interest rates or depreciation rates could be easily estimated.

ANALYSIS OF COSTS IN A SINGLE HOSPITAL

The same cost model applied so far to aggregate hospital data can also be applied to the costs incurred by a single hospital. As an example, data from a 520-bed midwestern community hospital for 1963, 1968, and 1973 were analyzed using the model that has been described. County population estimates for this application were made by a state planning agency [12] and by the Census Bureau [13]. Much of the data on this hospital, as well as the impetus for applying the model to an individual hospital, comes from an unpublished paper by John Jantz, a student in the University of Wisconsin's graduate program in health services administration.

The proportion of the increase in costs that is attributable to changes in each of the eight factors over the two five-year periods, 1963-68 and 1968-73, was calculated for this particular hospital and for the group of all not-for-profit short-term general hospitals. The results are shown in Table 3. Although the overall patterns are similar, there are several factors in both periods that differ significantly between the single hospital and the group of hospitals. Among the usage factors, the population served by this midwestern hospital did not exhibit the decline in the growth rate experienced in the U.S. overall, and accordingly population accounted for a greater proportion of the increase in cost for the single hospital. On the other hand, while inpatient admissions and outpatient visits were increasing for the U.S. generally, these

Table 3. Percentage Contribution of Eight Cost and Volume Factors to Changes in Total Costs of All Voluntary Short-Term General Hospitals and of One Midwestern Hospital

Factors	Percent of Cost Increase			
	1963-68		1968-73	
	All hospitals	Midwestern hospital	All hospitals	Midwestern hospital
All factors	100.0	100.0	100.0	100.0
Population ($\Delta_P C$)	8.2	15.9	7.0	12.8
Inpatient admissions ($\Delta_I C$)	3.6	-1.4	9.6	-3.8
Outpatient equivalent admissions ($\Delta_O C$) ..	1.9	-0.1	5.5	0.4
Inflation rate ($\Delta_I C$)	22.2	18.7	39.0	34.3
Deflated wages ($\Delta_W C$)	5.8	15.5	5.7	2.1
Staffing ($\Delta_S C$)	10.0	6.0	6.0	23.0
Deflated nonwage costs ($\Delta_N C$)	35.0	29.6	32.0	47.5
Length of stay ($\Delta_L C$)	13.3	15.8	-4.8	-16.3

factors were actually declining for the single hospital. These differential usage effects were observed in both five-year periods.

Although the impact of factors affecting unit costs in this hospital was generally similar to that observed nationally during the first five-year period, the staffing level and the daily nonwage costs exerted a much larger impact on the single hospital during the second five-year period. Another contrast observed is that the cost effect of length of stay decreased in this hospital by almost 16 percent, as compared with a drop of only five percent on the national level. The observed increase in cost effect of staffing level and daily nonwage costs for this hospital over the 1968-73 period was probably largely due to remodeling and expansion of the hospital's physical plant and facilities, which were done during this period.

DISCUSSION

In any use of this model, it must be remembered that the basic framework underlying all of these applications is simply a total cost identity—a statement that is true by definition. For any analysis based on this technique to be useful, the underlying identity must incorporate those variables which are deemed to be the factors of major concern in the given situation. In addition, it should be remembered that since the analysis is essentially based on a *definition* of total dollar costs, the model can be used to analyze the effect of different factors on total costs and indicate *how* costs have changed, but it cannot reveal *why* the observed change occurred. It may suggest hypotheses as to underlying causes, but it cannot be used to test such hypotheses in a statistical sense. Nevertheless, by identifying factors with significantly changed cost effect, it can perform a valuable function by directing attention to areas where further detailed analysis would be fruitful.

Once an appropriate cost model or definition has been established, it

can be used in a variety of ways and at several different levels of aggregation. Accountants and financial managers have found this technique to be a useful aid in the planning and control of costs in business firms. This article illustrates its use in analyzing hospital costs, both at the level of a single institution and at the macro level of a major sector of the health care system.

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